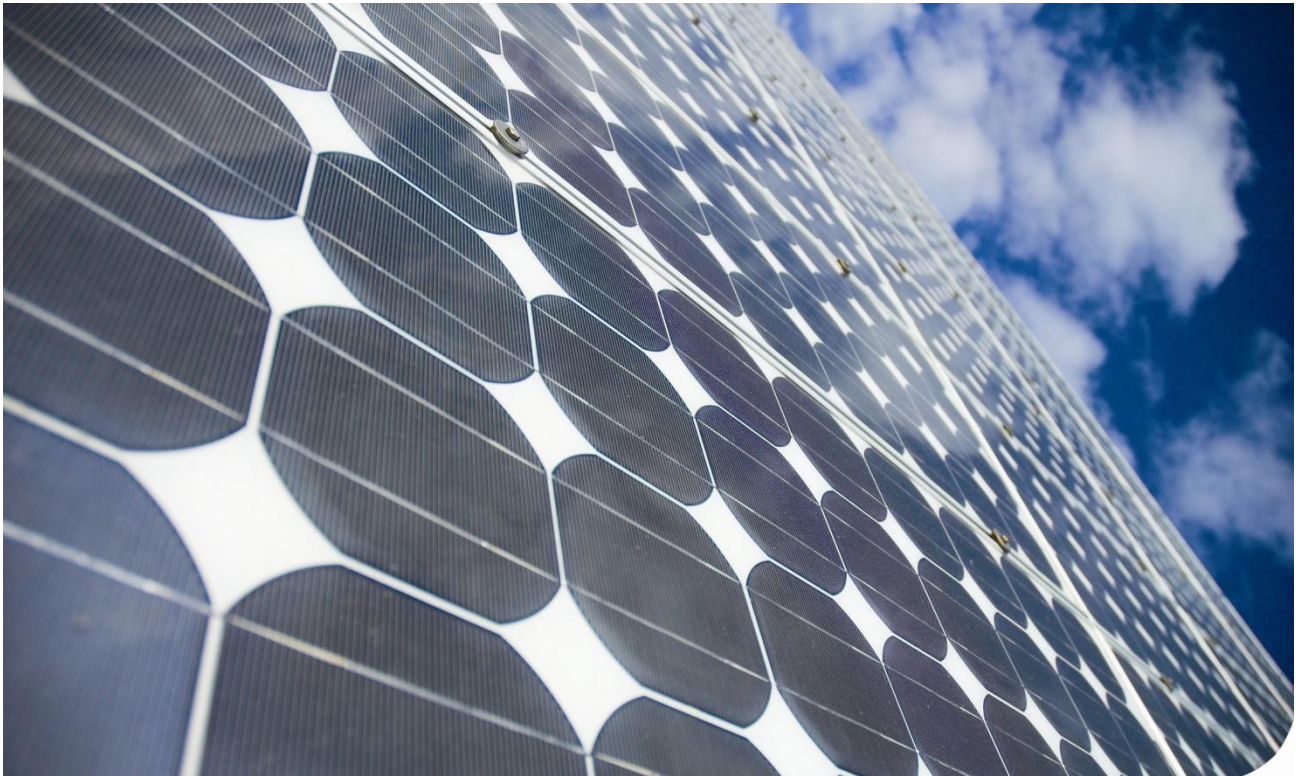




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Planning & Modeling for High-Penetration PV
CSI1 PM for HPPV | CPUC ID: 161
SunPower R6105

Preliminary Report of End-User Requirements

High-penetration PV Model Software Summary



SUNPOWER

California Public Utilities Commission
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Prepared by KEMA, Inc.
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Table of Contents

1.	Introduction	1-1
1.1	Steady State Model.....	1-1
1.2	Voltage Regulation	1-2
1.3	Transient Voltages	1-2
1.4	Dynamic Stability	1-2
2.	Software Vendors and Products.....	2-3
2.1	Basic Software Features	2-4
2.2	Analysis Features	2-6
2.3	Equipment Models	2-7
2.4	Data Editing and User Interface	2-8
2.5	Reports and Export Files	2-9
2.6	Additional Features	2-9
3.	Software Assessment	3-10
3.1	Evaluation of Software	3-10
A.	Vendor Software Survey Summary	A-1
B.	Additional Vendor Information	B-1
C.	Survey Summary of selected End-Users.....	C-1

List of Exhibits:

Figure 1 – Planning and System Analysis Software	2-3
Figure 2 –Basic Features Needed for System Analysis Software	2-4
Figure 3 - Features Provided for High-penetration PV Modeling Capability	2-7
Figure 4 - Equipment Model Summary by Vendor	2-8

1. Introduction

The California Public Utilities Commission (CPUC) has retained KEMA through SunPower to develop Technical Specifications for system models, reference data sets, and recommendations for integration of high-penetration PV systems into electric power system planning and operations. These models should accurately represent the power output variability of high-penetration PV installations for integration with traditional system planning and operations tools, such as load flow, short-circuit, and dynamic stability software packages.

The end-user is the host utility system planner that uses the load flow, short-circuit, or dynamic stability software programs that would incorporate these PV Models to assess the impact on the host electric utility system. Utilizing improved models that accurately represent the power output variability of PV installations will enable the end-user to more accurately assess peak and off-peak load capacity issues, system protection schemes, and improvements in reliability and power quality. Harmonics and voltage flicker are also important issues for the end-user when assessing high-penetration PV installations.

1.1 Steady State Model

The steady state PV model would be used in conjunction with the power flow software by the end-user to address peak load capacity issues and various impacts of large-scale PV interconnections. The power flow software used for transmission planning and adequacy studies within the WECC is GE's PSLF. End-users in many other areas of the country also use either PSLF or the Siemens PSS/E software for transmission planning, as well as a host of other packages. All of these packages produce accurate, high-quality results, with varying levels of sophistication. The PV model for transmission planning would need to be compatible with both of the 2 major transmission planning platforms used extensively throughout the industry, as well as a host of others with PV model capability.

For distribution planning, there are a wide variety of products available. Distribution planning applications may require a few more studies than transmission-level studies, including motor start/voltage flicker analysis, the ability to analyze and coordinate protection and control (P&C) settings, and analyze harmonic injections as examples of studies that may be required.

1.2 Voltage Regulation

One feature that is required of the PV model for distribution power flow analysis is the ability to accurately reflect the impact of PV power output variability. The modeling software should be capable of performing many load flow calculations over a predefined study interval with varying PV power output and feeder load. For example, minute-by-minute load flows run over a 24-hour period may be desired by the end-user to determine the impact of PV output variability on distribution circuit voltage fluctuation and control.

1.3 Transient Voltages

The PV model should be capable of accurately reflecting the impact of transient voltages at the inverter outputs, as would occur for PV installations when cloud cover produces intermittent PV output feeding into the collector system. The high-penetration PV model should include inverter transient voltage fluctuations and inverter control settings. These input settings should include low voltage ride-through, low-voltage cut-off threshold, var output capabilities and/or voltage control settings, and transient fault contributions. This level of dynamic detail would be required for a second-by second load flow or a dynamic stability study.

1.4 Dynamic Stability

The PV model should be capable of accurately reflecting the impact that transient voltages would have on neighboring rotating machines or area transmission operations. Transient voltage spikes in the inverter output of a high-penetration PV installation could have negative impacts on neighboring machine behavior and/or transmission system performance. Similarly, introducing a high-penetration PV interconnection to a system, with proper inverter control settings, could have a positive impact on machine dynamic behavior. These are all questions that need to be answered by the end-user and would be most beneficial in a dynamic PV model.

2. Software Vendors and Products

Many different planning software packages are used around the country by end-users at various companies. All of these software packages are high quality tools for planning and analysis of electric transmission & distribution systems produced by highly qualified vendors. KEMA conducted a survey of the following planning software vendors:

Figure 1 – Planning and System Analysis Software

Name of Software	Vendor Name
SynerGEE	GL Group
DEW	EDD
NEPLAN	Busarello, Colt & Partner (BCP)
Dapper	SKM
OpenDSS	Electric Power Research Institute (EPRI)
Paladin	Power Analytics
CYMDIST	Cyme, Incorporated
GridLab-D	PNL
ETAP	Operation Technology
ERACS	ERA
DINIS	Fujitsu
WinMill	MilSoft
PSS/E	Siemens
PSLF	General Electric
Easy Power	ESA
Power Factory	DigSILENT
Power World	Power World Corporation

(Vendors highlighted in **RED** have not returned survey yet – will be removed in final report)

The software survey asked vendors various questions about PV modeling capability and possible future program enhancements to incorporate a high-penetration PV model and what that model would include. The survey and a summary of the responses are shown in Appendix A. Many of the software providers either already have PV modeling capability or have plans to include one in future releases, at varying levels of detail.

2.1 Basic Software Features

This section provides a list of the most important features required of system analysis software for studying high-penetration PV interconnections by the end-user. While many different software vendors exist that provide products with varying levels of computational and reporting features, there are certain basic features that are needed for the end-user to analyze the full impacts of high-penetration PV interconnections. These are summarized in the following table.

Figure 2 –Basic Features Needed for System Analysis Software

Analysis Type	Description of Desired Features
Load Flow	Ability to solve both radial and looped networks. Ability to model multi-phase loads. Allocates loads based on KWh, connected KVA, or REA method. Ability to model multiple generation sources. Ability to models DC systems and FACTS devices. Ability to perform a series of load flows corresponding to a load curve.
Short-Circuit	Ability to solve both radial and looped networks. Ability to solve balanced and unbalanced networks. Ability to calculate and report branch contributions for faults. Ability to model multiple generation sources. Ability to model PV inverter contributions and control settings.
Transient Stability	Ability to model multiple generators and their control systems. Ability to model multiple DG units. Ability to model PV inverter dynamic output and control settings.
Dynamic Stability	Ability to model multiple generators and their control systems. Ability to model multiple DG units. Ability to model PV inverter dynamic output and control settings.
Harmonics	Ability to perform harmonic calculations for system configuration and inverter harmonic injection.

Load Flow

Load flow analysis historically uses the Newton-Raphson iterative technique to solve for voltages and currents from the algebraic equations that describe the system network. The load flow is used to calculate bus voltages, branch power flows, losses, voltage drop, current

magnitudes and angles. These calculations are used to check for over/under voltage, overloads, and assess circuit or system losses.

Typically, transmission load flow software will model system loads at a bus, while most distribution load flow software models loads that are lumped at either the end of a line section or uniformly distributed over the line section. Software should have the ability to model loads as either wye or delta-connected, constant KVA, constant impedance, constant current, or any combination of these.

The ability to model DC systems and FACTS devices are highly desirable for studying high-penetration PV interconnections.

Short Circuit

Short Circuit analysis generally calculates fault currents for 3-phase, phase-phase, phase-ground, and double-phase-to-ground faults. The short circuit program should have the ability to calculate fault currents for individual faults, a series of faulted locations in the system, or every bus/node in the network. The calculations should provide RMS, asymmetrical, and peak values for any fault. Branch contributions to the fault would also be needed for protection assessment.

Since the short circuit analysis requires more than just 3-phase faults, the program needs to have the ability to model unbalanced networks.

Motor Starting

A desirable feature would be the ability to perform a “motor start” study or “motor start flicker” study. Typically, a motor start module would include the ability to model any one of 3 operation modes: running, locked-rotor, and soft start. The program needs to have the ability to model variable frequency drives, solid-state torque ramp and voltage control, solid-state current limit and ramp, shunt capacitance, and motor model parameters.

Voltage Regulation

Voltage regulation is very important when analyzing DR impacts. The software should have the ability to set high and low voltage limits, target voltages, and regulator settings. Of most concern to the end-user will be the program’s ability to determine transformer and regulator settings that meet all specified criteria, determine the amount of reactive power required to maintain a specified voltage, and calculate the size of shunt devices necessary to bring the voltage within the user-specified criteria.

To provide all of the functionality desired, the software should have the ability to perform multiple load flows that are based on a load curve (or set of load curves) and a PV output curve in order to determine the number of LTC, regulator, and capacitor control operations and whether or not they may interfere with each other in attempting to control to circuit or system voltage.

2.2 Analysis Features

Load flow analysis is the most fundamental capability required for system analysis, whether it involves the transmission or distribution system. The load flow model creates the fundamental foundation that is required for subsequent analysis capabilities that are described in this section. A balanced 3-phase load flow, used mainly in transmission planning, utilizes positive-sequence data and balanced 3-phase loads. Individual phase currents are not normally calculated. Distribution load flow software, utilizing the positive-sequence network data, can calculate branch phase currents based on connected load by phase. This load is usually allocated across the feeder to match projected peak feeder load (for radial systems).

Short Circuit analysis is the basis for understanding system faults that can destroy equipment and therefore critical for system protection schemes. The short circuit model utilizes positive, negative, and zero-sequence network data to calculate unbalanced fault currents. Individual phase and branch contributions are also necessary when evaluating protection and control settings. Adding high-density PV to a circuit or system may complicate the protection scheme, which needs to be evaluated by the end-user. It would be highly desirable for the end-user if the short-circuit program had the capability to export results to a protection coordination package or had the ability to produce time-current curves.

Dynamic stability analysis evaluates the dynamic interactions (less than 20 cycles) between rotating machines and DER installations, including PV inverters. The PV model should have flexibility (options and parameters) for use in dynamic stability. Inverter ramp rates, contributions to faults, and trip settings are all examples of features that are needed for accurate representation of high-density PV installations with the host utility system for dynamic studies.

The following table provides a list of analysis features provided by each vendor.

Figure 3 - Features Provided for High-penetration PV Modeling Capability

Desired Feature	Load Flow	Short Circuit	Dynamic Stability	Motor Flicker	TCC Curves
SynerGEE	Yes	Yes	No	Yes	No
DEW	Yes	Yes	No	Not sure	Not sure
NEPLAN	Yes	Yes	Not sure	Not sure	Not sure
Dapper	Yes	Yes	No	No	Yes
OpenDSS	Yes	Yes	No	No	No
Paladin	Yes	Yes	Not sure	Not sure	Not sure
CYMDIST	Yes	Yes	No	Yes	Yes
GridLab-D	Yes	Yes	Not sure	Not sure	Not sure
ETAP	Yes	Yes	Yes	Yes	Yes
ERACS	Yes	Yes	Not sure	Not sure	Not sure
DINIS	Yes	Yes	Not sure	Not sure	Not sure
WinMill	Yes	Yes	Yes	Yes	No
PSS/E	Yes	Yes	Yes	No	No
PSLF	Yes	Yes	Yes	No	No
Easy Power	Yes	Yes	Yes	Yes	No
Power Factory	Yes	Yes	Yes	Yes	No
Power World	Yes	Yes	Yes	Yes	No

2.3 Equipment Models

It goes without saying that lines, transformers, voltage regulators, shunt devices, and generator models are absolutely necessary for any realistic level of basic network modeling. The modeling of switches, protective devices, motors and other additional equipment, such as PV inverters are highly desirable for specific applications of interest to the end-user. The table below lists the types of additional equipment that each product currently models.

Figure 4 - Equipment Model Summary by Vendor

Product	Switches	Motors	Storage Devices	Protective Devices
SynerGEE	Yes	Yes	No	Yes
DEW	Yes	Yes	Not sure	Not sure
NEPLAN	Yes	Yes	Not sure	Not sure
Dapper	Yes	Yes	Not sure	Yes
OpenDSS	Yes	Yes	No	Yes
Paladin	Yes	Yes	Not sure	Not sure
CYMDIST	Yes	Yes	Not sure	Yes
GridLab-D	Yes	Yes	Not sure	Not sure
ETAP	Yes	Yes	Not sure	Yes
ERACS	Yes	Yes	Not sure	Not sure
DINIS	Yes	Yes	No	Not sure
WinMill	Yes	Yes	No	Not sure
PSS/E	Yes	Yes	Not sure	No
PSLF	Yes	Yes	Yes	No
Easy Power	Yes	Yes	Yes	Yes
Power Factory	Yes	Yes	Yes	Not sure
Power World	Yes	Yes	Yes	Not sure

2.4 Data Editing and User Interface

The user interface for each of the products listed is designed with a one-line diagram display of the network from which the end-user can create, edit, and navigate the network model. This one-line graphic display interface is referred to as the GUI (Graphic User Interface). Typically, the user can zoom in or out on a selected portion of the model. This type of editing capability makes the software more usable for the first-time user and is almost essential.

The ability to edit data from tabular equipment summaries is also a very desirable feature, especially when dealing with large system models where the GUI may not be the most easy to navigate and locate the desired equipment data.

2.5 Reports and Export Files

Each product can provide standard or customized tabular reports. Many can export output files to an Excel Spreadsheet format for use in reports and further manipulation and editing by the end-user. This capability makes it much easier to for the end-user to document the study results.

2.6 Additional Features

Many of the products provide additional features such as optimization tools. While these tools and their application is not the main subject of this report, having such tools within the capability of the product can provide further benefit for the end-user. Optimization of feeder losses, tie-point optimization, optimal power flow (OPF), and capacitor placement and sizing optimization are all desirable features, but not required for modeling of high-penetration PV installations.

3. Software Assessment

Having completed a survey of system analysis software vendors, it is apparent that the industry recognizes the need to incorporate PV inverter models into their product capability to meet the growing needs of end-user requirements. The development of an industry-standard PV inverter model represents an important new application for utility end-users to accurately represent and assess the effect of PV inverter output variability and control settings as well as short-circuit and dynamic characteristics on the host electric utility system performance

To assess the capability of currently available software, two surveys were conducted. One survey was sent to a few selected end-users that have familiarity with the PV modeling effort underway at the WECC Renewable Energy Modeling Task Force, in order to get input from the end-user. The second survey was sent to known software vendors to assess the capability of the products currently available to the end-user. The details of those surveys are contained in the Appendix..

3.1 Evaluation of Software

The commercially available tools for system analysis were basically designed for either distribution planning used for radial systems, or transmission planning for network systems. A few products were developed with the versatility for either application, such as Easy Power. All of the distribution software products have load flow and short-circuit modules, while some provide protection coordination capability. Most do not have dynamic modeling capability. All of the transmission software products have load flow, short-circuit, and dynamic stability modules, but do not have system protection coordination capability. None of the products are versatile enough to do everything required by the end-user.

Recommending a software package that can be used for all end-user applications would be a very difficult task. However, there are several packages that are fairly versatile and can be used to study the impact of high-penetration PV on the system with the use of an industry-standard PV inverter model. Most vendors have indicated some form of current PV modeling capability or have plans to include such a model a future release of their product.

Without knowing the details of each vendor's plans, it can be stated that the quality and capability of these products as a whole is extremely good. It probably goes without saying that the enhancement for each of the products would meet the standards being set forth by the

“WECC Guide for Representation of Photovoltaic Systems in Large-Scale Load Flow Simulations”, being prepared by the WECC Renewable Energy Modeling Task Force.

This type of software tends to be market-driven. If the industry and the end-user request high-penetration PV modeling capability as a required feature of the product, then the product vendor will generally provide it with an enhancement, as we have generally seen in the results of the vendor survey summary

A. Vendor Software Survey Summary

Software Name:	Power World	Grid Lab-D	DEW	Power Factory	Easy Power	NEPLAN	Paladin	SynerGEE	PSLF	Open DSS	WinMill	DINIS
Load-Flow												
PV is modeled using Generator Type Model	Yes	No		Yes ¹	Yes	Yes	Yes	Yes	Yes	No ¹	Yes	Yes ¹
PV is modeled using Negative Load Type Model	Yes	Yes		No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PV is modeled using Inverter Type Model	Yes	Yes	Yes	see above.	Yes	Yes	Yes	Yes	No	No	No	No
Are there plans to add a discrete PV model?		Yes ¹		Yes ²	Yes ¹	Yes ¹	Yes ¹	No ¹	No	Yes ²	Yes	
Can loadflow be controlled using "scripting" language	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes ²
Can loadflow be accessed thru interface (COM / SOAP / API)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes
Can loadflow solve mesh networks	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Can loadflow solve unbalanced networks / unbalanced loads	No	Yes	Yes	Yes	No	Yes	No ²	Yes	No	Yes	Yes	Yes
Can line impedances be calculated from pole geometry & wire characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Can application model 3 - 1 ph regulators on 3 ph line section	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Do regulator controls operate based on time period	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	
Do capacitor controls operate based on time period	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	

Software Name:	Power World	Grid Lab-D	DEW	Power Factory	Easy Power	NEPLAN	Paladin	SynerGEE	PSLF	Open DSS	WinMill	DINIS
Does application have model for distribution transformer (120/240 volt secondary)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes ²		Yes	Yes	Yes ⁵
Can application remove all generators with single command	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Can application lock all regulator taps with single command	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Can loadflow be solved over a time period (i.e. day, week, year)	Yes	Yes	Yes	Yes	???	Yes		Yes	No ¹	Yes	No ³	Yes ³
Can PV be associated with "generation curve" over a time period	Yes	Yes	Yes	Yes	???	Yes	Yes	Yes	No ¹	Yes	No	
Can Load be associated with "load curve" over a time period	Yes	Yes	Yes	Yes	???	Yes	Yes	Yes	No ¹	Yes	No	Yes ³
Can program calculate voltage flicker?	No	No	Yes	Yes	Yes	Yes	Yes ³	Yes	No	No ³	Yes	Yes ⁴
How does the program calculate voltage flicker for steady-state?	N/A		Yes ¹	Yes ³		Yes ²	Yes ³	Yes ³		--- ⁴	Yes ¹	Yes ⁴
Can loadflow calculate peak values (Load, Losses) (kW, kvar, kVA)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Can loadflow calculate energy values over time period (kWh) (load, losses)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes		Yes	No	No
Can program allocate load based on source current by phase	No	No	Yes	Yes	???	Yes	No ²	Yes	No	Yes	Yes	Yes
Does application have pre-defined tabular reports	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Does application have pre-defined summary reports (Voltage Drop, Losses, equipment)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Software Name:	Power World	Grid Lab-D	DEW	Power Factory	Easy Power	NEPLAN	Paladin	SynerGEE	PSLF	Open DSS	WinMill	DINIS
Does application have geographic plots	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes
Does application have profile plots	Yes	No	Yes	Yes	No	Yes	Yes	Yes		Yes	Yes	No
Can application export results to EXCEL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Can program handle energy storage options associated with DER (Distributed Energy Resources)?	No	Yes	Yes ²	Yes	???	Yes	Yes	Yes ⁴	Yes	Yes	No	Yes
Can program handle user-defined models for PV or ES (Energy Storage) installations?	No	Yes	Yes	Yes	???	Yes	Yes	No	Yes	Yes ⁵	Yes	No
Short - Circuit												
PV is modeled using Generator Type Model	No	No		Yes ¹	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PV is modeled using Inverter Type Model	No	No		see above	Yes	Yes	Yes	Yes	Yes ²	Yes ⁹	No	No
PV is modeled using Constant Current Type Model	No	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes ¹⁰	No	Yes
Can program calculate 4 fault type (SLG, LL, LLG, 3 ph)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No ⁶	Yes	Yes
Can program calculate X/R ratios	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Can program calculate apparent impedances	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Can program calculate branch contributions for mesh networks	Yes	No	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Does application have pre-defined tabular reports	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Software Name:	Power World	Grid Lab-D	DEW	Power Factory	Easy Power	NEPLAN	Paladin	SynerGEE	PSLF	Open DSS	WinMill	DINIS
Does application have pre-defined plots	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	
Does application have profile plots	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	
Can program export results to EXCEL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Can program handle user-defined models?	No	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes ⁵	Yes	No
Are there plans to integrate DER-models if None currently exist?	No			Yes ²	???	Yes ¹	Yes ⁴	Yes ⁵	No	Yes ⁷	Yes ²	Yes
Dynamics												
Can program perform dynamic simulations?	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Does current program model PV as a Generator Type Model?	Yes	No		Yes ¹	Yes	Yes	Yes	Yes	No ³	Yes	Yes	Yes
Does current program model PV as an Inverter Type Model?	Yes	No		see above	Yes	Yes	Yes	Yes	Yes	No ³	No	Yes
Does current program model PV as a Negative Load Type Model?	Yes	No		No	Yes	Yes	Yes	Yes	No	No	Yes	Yes
If Not, are there plans to include a PV model in a future release?		No		Yes ²		Yes ¹	Yes ¹	Yes ⁵		Yes ³	Yes ²	
Can program export results to EXCEL?	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Can program Plot PV transmission voltage vs. time?	Yes	No		Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Can program Plot PV power output (real and reactive) vs. time	Yes	No		Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Does model allow Low Voltage Ride-thru capability?	Yes	Yes		Yes	???	Yes	Yes	No	Yes	Yes	No	

Appendices

Software Name:	Power World	Grid Lab-D	DEW	Power Factory	Easy Power	NEPLAN	Paladin	SynerGEE	PSLF	Open DSS	WinMill	DINIS
Can PV Model provide dynamic reactive support?	Yes	Yes		Yes	???	Yes	Yes	No	Yes	Yes	Yes	
Does PV Model trip on transmission level disturbances (1.e. voltage sag)?	Yes	Yes		Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Does program have energy storage (ES) model?	Yes	Yes		Yes	???	Yes	Yes	Yes ⁶	Yes	No ⁸	No	No
Can program handle user-defined models for PV or ES installations?	No	Yes		Yes	???	Yes	Yes	No	Yes	Yes ⁵	No	No
Are there plans to integrate DER-models if None currently exist?				Yes ²	???	Yes ¹	Yes ⁴	No		Yes	Yes	

Software Vendor Notes (from table above)

Power World	
1	
Grid Lab-D	
1	Already has one
DEW	
1	Two power flow runs are used with modeling generation/load changes and controllers are frozen
2	Batteries are modeling
Power Factory	
1	A special "Static Generator" model is supported.
2	Already available.

3	time series must be generated and fed to the "flicker meter"
Easy Power	
1	very soon
NEPLAN	
1	already integrated
2	NEPLAN is calculating short and long-term flicker Pst and Plt. The calculation depends on size of voltage dip and repeat rate of the current/power change. See standard "D-A-CH-CZ Technical Rules for the Assessment of Network Disturbances". The calculation is made for single and 3-phase consumers/production. Special treatment is done for WTs & wind farms. Superposition method also integrates different flicker sources.
Paladin	
1	Model will be included with DesignBase 4.0, slated to come out this summer.
2	Unbalanced phase under development.
3	This is Not accomplished with our load flow module, but with our Transient Stability module.
4	Models already exist.
SynerGEE	
1	SynerGEE contains a DGEN model which is assigned to primary line section.
2	Currently SynerGEE does Not support center tap distribution transformers.
3	The voltage flicker is determined by comparing the loadflow before/after results.
4	SynerGEE Large Customer model supports both generation contributions by generation curve and fixed load contribution.
5	TBD based on engineering and development resources.
6	The generator models can be scheduled based on the generation load curves.
PSLF	
1	Time based dispatch/load profile can be fed to the tool and the load flow can be solved for each dispatch/load profile. This can be accomplished using epcl scripting language. GE MAPs can be used to get Security constrained unit commitment and dispatch for time based load profile.
2	Can be modeled as negative load. Depends upon user's preference.
3	i.e. PV is Not modeled with a conventional generator
Open DSS	
1	Not for power flow; for dynamics only at present
2	The "PVSystem" model is already added for power flow. A dynamic model is under development for 2011

3	Will probably be added end of 2011 or early 2012. Presently done by separate program.
4	10s symmetrical time-domain waveform is reconstructed and fed into IEC flickermeter model
5	Requires good programming skills
6	Does not calculate LL-G Faults
7	Already Available
8	Storage model does Not currently have dynamics model implemented
9	Thevenin equivalent similar to Generator
10	User could do this by changing model type
WinMill	
1	change in pre-start voltage to locked rotor voltage
2	Plans are for Inverter Type Models to be developed in next 18 months
3	Analysis is static where load model represents a point in time.
DINIS	
1	PV or PQ generators
2	API module supports VB, VB.Net and Java.
3	Time Of Day module or Load Management module allows the analysis over a time period. The API can be used to create an application that can read real time load information.
4	Fault analysis can be used to calculate the voltage profile during a motor start. Transient analysis can be used to calculate the voltage variations due to events such as switching, motor/generator start-up, etc.
5	Pgm supports the analysis of EHV. HV and distribution networks.

B. Additional Vendor Information

Company	Product	Web Site
MilSoft	WinMill	www.milsoft.com
DigSilent	Power Factory	www.digsilent.de
GL-Group	SynerGEE	www.gl-group.com
EPRI	OpenDSS	www.sourceforge.net/projects/electricdss/
Cyme	CYMDIST	www.cyme.com
ESA	Easy Power	www.easypower.com
PNL	GridLab-D	www.gridlabd.org
EDD	DEW	www.edd-us.com
Operation Technology	ETAP	www.etap.com
Power Analysis	Paladin	www.poweranalytics.com
BCP Busarello Cott Partner AG	NEPLAN	www.neplan.com
SKM	Dapper	www.skm.com
ERA	ERACS	www.era.co.uk/services/eracs.asp
Fujitsu	DINIS	www.dinis.com
Siemens	PSS/E	www.usa.siemens.com/energy/
GE	PSLF	www.ge-energy.com/products_and_services/
Power World	Power World	www.powerworld.com

C. Survey Summary of selected End-Users